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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte KEVIN P. MARTIN,
HARRY P. GILLIS, and DIMITRI A. CHOUTOV
APPELLANTS

Appeal 2008-2158
Application 10/784,697¹
Technology Center 1700

Decided: May 20, 2008

Before EDWARD C. KIMLIN, TEDDY S. GRON, and MARK NAGUMO,
Administrative Patent Judges.

Opinion for the Board filed by *Administrative Patent Judge* MARK
NAGUMO.

Opinion Dissenting-in-Part and Concurring-in-the-result filed by
Administrative Patent Judge TEDDY S. GRON.

NAGUMO, *Administrative Patent Judge*

DECISION ON APPEAL

¹ Application filed 23 February 2004, titled *Method and Apparatus for Low Energy Electron Enhanced Etching of Substrates in an AC or DC Plasma Environment*. We refer to the “697 Specification,” and cite it as “Spec.” The real party in interest is listed as Georgia Tech Research Corporation. (Appeal Brief under 37 C.F.R. § 1.192 filed 15 December 2006 (“Br.”), at 2.)

A. Introduction

Kevin P. Martin, Harry P. Gillis, and Dimitri A. Choutov (“Martin”) appeal from the rejection of claims 1, 2, 4-7, 9-11, and 16-26 of application 10/784,697, which are all of the pending claims. We have jurisdiction under 35 U.S.C. § 6. We AFFIRM-IN-PART.

The claimed subject matter relates to an apparatus for etching substrates with the assistance of low energy electrons. Martin calls the process “Low Energy Electron Enhanced Etching,” or “LE4,” for short. The presently claimed method appears to be a development or improvement of subject matter claimed in the Continuation-in-Part parent application, which has issued as the 538 Patent.² The principal differences in the described and claimed subject matter of the 697 application and the 538 patent appear to be the placement of the substrate to be etched on a support that is not the anode of a DC cold cathode glow discharge, as in the 538 patent claims, and the relaxation of the requirement in the 538 patent claims that “a species reactive with the substrate” be present during etching.³

The Examiner has maintained the following grounds of rejection⁴:

A. Claims 1, 2, 4-7, 9-11, and 23-25 have been rejected under 35 U.S.C. § 112(2). (Ans. 15.)

² Kevin P. Martin *et al.*, *Method and Apparatus for Low Energy Electron Enhanced Etching of Substrates*, U.S. Patent 5,882,538 (“538 patent”) issued 16 March 1999, from application 08/705,902, filed 28 August 1996.

³ Cf. 538 patent claims 1 and 15 (538 Patent 13:3-5 and 14:1-11).

⁴ Rejection mailed 1 August 2006; Examiner’s Answer mailed 28 June 2007 (“Ans.”).

- B. Claims 1, 2, 4-7, 9-11, and 23-25 have been rejected under 35 U.S.C. § 103(a) in view of the combined disclosures of Hayashi⁵ and Lee⁶. (Ans. 3-6.)
- C. Claims 16-18 have been rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Hayashi and Kofuji⁷ (Ans. 6-11.)
- D. Claims 19-22 and 26 have been rejected under 35 U.S.C. § 103(a) in view of the combined teachings of Hayashi, Kofuji, and Lee. (Ans. 12-14.)

B. Discussion

On appeal, the burden of going forward rests on the appellant to show reversible error in the Examiner's findings of fact or conclusions of law.

Claim 1 reads:

An apparatus [10] for low-damage anisotropic electron dry etching of a substrate [16], comprising:

[a] a plasma reactor [11] for containing a plasma [36, 37]; and

[b] a mechanical support [12] within said plasma reactor adapted to receive said substrate, said mechanical support isolated from the creation of the plasma;

⁵ Yutaka Hayashi *et al.*, *Method of Gas Reaction Process Control*, U.S. Patent 4,950,376 (21 August 1990).

⁶ Young H. Lee, *Plasma Reactor for Processing Substrates Comprising Means for Inducing Electron Cyclotron Resonance (ECR) and Ion Cyclotron Resonance (ICR) Conditions*, U.S. Patent 5,279,669 (18 January 1994).

⁷ Naoyuki Kofuji *et al.*, *Surface Treatment Method and System*, U.S. Patent 6,231,777 B1 (15 May 2001).

Indefiniteness

The Examiner has determined that there is insufficient antecedent basis for the limitation “the creation of the plasma” in part [b] of claim 1 because the claim does not recite any plasma creation means. (Ans. 15.) The Examiner argues that a person of ordinary skill in the art would not have been able to determine the metes and bounds of the claims, “since it is unclear whether the claim includes a means for creating plasma (and if so, what means that might be).” (Ans. 18.) Accordingly, the Examiner holds that claim 1 and all claims dependent on claim 1 are indefinite. (Ans. 15.)

The Federal Circuit has held that despite the absence of explicit antecedent basis, “If the scope of a claim would be reasonably ascertainable by those skilled in the art, then the claim is not indefinite.” *Bose Corp. v. JBL, Inc.*, 274 F.3d 1354, 1359 (Fed. Cir. 2001). Moreover, the court has held that antecedent basis can be present by implication. *Slimfold Manufacturing Co., Inc. v. Kinkead Industries, Inc.*, 810 F.2d 1113, 1116 (Fed. Cir. 1987). *See, Energizer Holdings, Inc. v. Int’l Trade Comm’n*, 435 F.3d 1366, 1370-71 (Fed. Cir. 2006) (discussing these cases with approval).

Here, the recitations in claim 1 and in the supporting description in the specification (Spec. 6-7) that the apparatus is for electron dry etching of a substrate, and that it comprises a plasma chamber for containing a plasma provide adequate antecedent basis by implication of a plasma generator. The Examiner’s concerns regarding the scope of the “means for creating a plasma” (Ans. 18) are misplaced. In the absence of “means-for” language in the claims requiring construction of the corresponding structure disclosed

in the specification under 35 U.S.C. § 112(6), "breadth is not to be equated with indefiniteness." *In re Miller*, 441 F.2d 689, 693 (CCPA 1971).

The rejection for indefiniteness is REVERSED.

Rejections over Prior Art

With respect to rejection B, Martin presents distinct arguments for patentability only for claim 1. Accordingly, the dependent claims stand or fall with independent claim 1.

In rejection B, the Examiner finds that Hayashi discloses an apparatus meeting limitations [a] through [c]. (Ans. 3.) The Examiner also finds that Hayashi does not disclose low-damage anisotropic electron dry etching or a pulse waveform power source that biases the additional structure to direct electrons from the plasma towards the substrate for etching. (*Id.*) The Examiner finds that Lee discloses a grid **60** that is biased by a pulsed power supply, and that Lee discloses that the grid can be used to extract positive or negative ions from a plasma to etch a substrate. (*Id.* at 3-4, citing Lee 6:50-7:25.) The Examiner reasons that it would have been obvious to modify Hayashi by substituting the grid **60** and pulsed power supply taught by Lee in order "to generate a pulsed charged-particle beam with a desired base voltage." (*Id.* at 4.) The Examiner argues that, "[s]ince both the positive dc electrical bias power source taught by Hayashi et al. and the ac pulse waveform power source taught by Lee are variable power sources, the combination of the two power sources would be structurally capable of being set at sufficient voltage so as to provide sufficient energy for the electrons to etch material from the substrate." (Ans. 4.) The Examiner acknowledges that low-damage anisotropic electron dry etching is not

mentioned by Hayashi or Lee. (*Id.* at 5.) But, the Examiner argues, because the combined structure would be structurally capable of performing that function, the claims do not distinguish over the prior art. (*Id.*)

Generally, Martin argues that the Examiner has failed to give proper weight to the functional limitations of the claimed subject matter. (Br. at 5-7.) Specifically, Martin does not dispute any of the Examiner's findings regarding Hayashi. Indeed, Martin concedes that each reference relates to ion etching, and "[e]ach use a plasma gas, from which either electrons or ions are accelerated towards a substrate for etching." (Br. 8.) Martin notes that due to the difference in mass, the mobility of the electrons is higher than the mobility of the ions. (Br. 8.) "Additionally," Martin argues, "electrons and ions appear in different quantities within the plasma and respond differently to the electrical fields they encounter." (*Id.*) It is not clear what Martin would have us make of this statement. Assuming most ions in a plasma are positive because it is relatively easier to knock electrons off than to add them on, there will be more electrons than ions due to multiple ionization. It is also true that positive and negative ions respond to a given electric or magnetic field equally but with opposite sign: but Martin does not explain what other difference, if any, it would have us understand from its argument. Martin continues, "[a] waveform used to accelerate ions for etching does not accelerate electrons towards the substrate with sufficient energy to actually etch the substrate." (Br. 8-9.) Martin asserts further that the pulse waveform power source taught by Lee is incapable of causing electron etching of substrates. (Br. 9.) But Martin has not directed our attention to any credible evidence in the record supporting either of these "findings."

An attorney's argument in a brief cannot take the place of evidence. *In re Pearson*, 494 F.2d 1399, 1405 (CCPA 1974). As Martin's arguments are devoid of supporting credible evidence, we decline to give these arguments any weight.

Martin argues further that "Lee uses electron cyclotron resonance (ECR) 'thereby keeping electrons confined within plasma 16' (col. 9, line 16 [sic:6].)" (Br. 11.) This argument appears to be misdirected, as the complete sentence cited by Martin reads: "In plasma reactor 10, shown in **FIG. 1**, hollow cathode 22 is allowed electrically to float above ground potential, thereby keeping electrons confined within plasma 16." (Lee 9:4-7.) Thus, the role of ECR in confining the electrons in the plasma is not established by this passage, as that role is expressly assigned to the positive potential of the hollow cathode. Martin repeats its earlier argument that "the biased voltage on extraction grid 60 does not provide 'sufficient energy for electrons to etch material from the substrate' as claimed." (Br. 11.) But Martin has not further explained its argument, and again, Martin has not directed our attention to any credible evidence of record supporting this conclusion.

Martin argues further that "[s]ignificant changes are required to convert an ion etching apparatus to an electron etching apparatus as claimed." (Br. 11.) Martin does not, however, state what these changes are, nor does Martin direct our attention to any credible evidence of record indicating what sort of changes might be needed. Moreover, Martin does not indicate why the changes would have been beyond the level of ordinary skill. Indeed, considering the silence of Martin's specification as to what changes are necessary, we conclude that all the ordinarily skilled worker

would have needed was the suggestion to use electrons to etch the substrate. Finally, Martin submits “that the alleged pulse waveform power source of Lee is not capable of, or configured to ‘bias the additional structure to direct the electrons from the plasma towards the substrate, the bias providing sufficient energy for the electrons to etch material from the substrate’ as recited in claim 1.” (Br. 12.) Again, however, Martin has not directed our attention to any credible evidence of record supporting this argument.

The question is, has Martin shown that the Examiner has committed reversible error in concluding that a prima facie case of obviousness has been established?

Given that Martin does not challenge the Examiner’s reliance on Hayashi except to note, accurately, that Hayashi does not teach electron etching, and given the paucity of credible evidence submitted by Martin in support of its charge of error to the Examiner, we conclude that Martin has not carried its burden. We note that the Examiner points out that Lee teaches etching substrates, and further that both positive and negative ions can be extracted from the plasma and directed towards the substrate. (Lee 6:50-60.) Martin concedes both points: that Lee is directed to methods of etching and that Lee teaches using “a plasma gas, from which either electrons or ions are accelerated towards a substrate for etching.” (Br. 8.) Moreover, an electron is negatively charged, like a negative ion, and will have the same potential energy in an electric field as a negative ion having a charge of minus one. The Examiner’s conclusion that Lee’s biased grid **60** provides sufficient energy available to induce electron etching is thus not unreasonable, and rebuttal by Martin requires something more than mere attorney denial or argument. *Cf. In re Spada*, 911 F.2d 705, 708 (Fed.

Cir. 1990) (“[W]hen the PTO shows sound basis for believing that the products of the applicant and the prior art are the same, the applicant has the burden of showing that they are not.”).

Accordingly, the rejection of claim 1 and claims dependent on claim 1 in view of the combined teachings of Hayashi and Lee is AFFIRMED.

Rejections C and D deal with means-plus-function claims for a low damage anisotropic electron dry etching apparatus. Claim 16 is representative, and Martin has not argued patentability on the basis of any other claim.

The Examiner finds that Hayashi describes an apparatus meeting the various limitations of claim 16 but for the electron etcher means, which the Examiner identifies as the pulse waveform power supply attached to the substrate. (Ans. 7-8.) The Examiner finds that Kofuji describes providing pulses to the substrate that attract electrons to the substrate during the “positive swing of the pulsed electrical bias.” (Ans. 8.) The Examiner then finds that Kofuji describes the electron etcher means recited in claim 16, and argues that it would have been obvious to modify the Hayashi apparatus to include the etcher means taught by Kofuji in order to avoid notching and charge build-up on the substrate during etching. (Ans. 8.) The Examiner finds that Hayashi includes a positive variable dc-electrical bias power source connected to the substrate holder, and concludes that the combination with the ac-pulse waveform power source provided by Kofuji would provide a power source structurally capable of directing electrons from the plasma towards the substrate. (Ans. 8-9.) The Examiner concludes that “[d]uring the positive swing of the pulse waveform power source, negative particles,

including electrons, would be directed to the substrate to perform etching” (*Id.* 9.)

With respect to rejections C and D, Martin presents distinct arguments for patentability only for claim 16. Accordingly, the dependent claims stand or fall with the independent claims. Moreover, Martin does not dispute any of the Examiner’s constructions of the means-plus-function limitations. We therefore accept Martin’s silence as an admission that the Examiner’s analysis of the means-plus-function limitations, which we do not find unreasonable, is correct.

Martin objects first that Hayashi does not teach electron etching. (Br. 13.) Martin argues further that Kofuji does not disclose electron etching, but only neutralization of the charge on the substrate. The electrons in Kofuji’s apparatus, according to the Martin, “do not receive enough bias to actually ‘etch material from the substrate,’ as claimed.” (*Id.*)

The weight of the evidence supports Martin. The pulsed power provided by Kofuji is directed towards neutralizing charge build up on the substrate in order to prevent “electron shading” and associated deleterious consequences. (Kofuji 2:13-15.) The Examiner has not directed our attention to any credible evidence that the bias suggested by Kofuji would be sufficient when combined with Hayashi to provide, as required, “sufficient energy for the electrons to etch material from the substrate.” Nor has the Examiner shown why, if a bias greater than that necessary for Kofuji’s purpose were needed to obtain electron etching, it would have been obvious, given the teachings of Hayashi and Kofuji, to provide it.. Accordingly, the rejections of part C are REVERSED. The rejections of claims under part D

build on the rejections set out in part C. As Lee is not relied on for teachings of an electron etcher means—i.e., an apparatus providing a pulsed bias to the substrate—the rejections set out in part D are also REVERSED.

The Examiner's arguments that the structure (apparatus) alleged to have been obvious over the combined teachings of Hayashi and Kofuji would have been capable of performing the electron etching recited in the claims illustrate the pitfalls of relying on an argument for the existence of an inherent property in an obviousness rejection. When such a property—as here—is argued to arise only out of the combination of references, obviousness does not lie. *Cf. In re Rijckaert*, 9 F.3d 1531, 1534 (Fed. Cir. 1993) ("That which may be inherent is not necessarily known. Obviousness cannot be predicated on what is unknown." (Citation omitted).).

C. Summary

In view of the record and the foregoing considerations, it is:

ORDERED that the rejection of claims 1, 2, 4-7, 9-11, and 23-25 under 35 U.S.C. § 112(2) is REVERSED;

FURTHER ORDERED that the rejection of claims 1, 2, 4-7, 9-11, and 23-25 under 35 U.S.C. § 103(a) in view of the combined disclosures of Hayashi and Lee is AFFIRMED;

FURTHER ORDERED that the rejection of claims 16-18 under 35 U.S.C. § 103(a) in view of the combined teachings of Hayashi and Kofuji is REVERSED;

FURTHER ORDERED that the rejection of claims 19-22 and 26 under 35 U.S.C. § 103(a) in view of the combined teachings of Hayashi, Kofuji, and Lee is REVERSED;

FURTHER ORDERED that no time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a).

AFFIRMED-IN-PART

GRON, dissenting-in-part; to the extent concurring, concurring-in-the-result only.

I am struck by three statements in the description of the claimed invention that support Appellants' arguments. These passages were also present, with the exception of a single phrase, in the CIP parent application, which issued as the 538 Patent, and they explain, in my view, why the Examiner has not satisfied the PTO's initial burden to establish a prima facie case of obviousness for any of Appellants' claims.

First, the Specification teaches that, "[t]o minimize etch damage, reactive species generated in the plasma should have energies larger than the activation energy of the etch reaction (a fraction of an eV), but less than the energy required for atomic displacement (3 to 10 eV for III-V semiconductors)." (Spec. 4, ¶ 13; 538 Patent 3:2-10;⁹ emphasis added.)

Second, in describing the Low Energy Electron Enhanced Etching (LE4) process, the Specification teaches:

In contrast to the above-described reactive ions [produced in Reactive Ion Etching, "RIE"], the low energy electrons that are used in the present invention travel at less than about 100 electron volts (eV) kinetic energy (KE), preferably at less than about 20 eV. The mass of electrons is many orders of magnitude smaller than the mass of ions and the electrons carry essentially no momentum to the surface. Therefore, they do not damage the surface.

⁹ See also H.P. Gillis *et al.*, *Low Energy Electron-Enhanced Etching of GaAs(100) in a Chlorine/Hydrogen DC Plasma*, 68 *Appl. Phys. Lett.* 2255 (1996) (of record), citing references dating from 1986 to 1990 for the energies. Thus, the recited parameters reasonably appear to have been well known in the art.

(Spec. 6, ¶ 19; 538 Patent 3:62-4:2; emphasis added.) From this statement and the preceding statement, both of which also appear in the CIP parent application, it appears reasonable to conclude that the electrons themselves would not etch the surface of a substrate.

Third, the Specification teaches:

In one aspect, the invention involves a process for low-damage, anisotropic etching of a substrate that includes the steps of placing the substrate *on a mechanical structure designed to support the sample to be etched within a plasma reactor* and subjecting the substrate to a plasma including low energy electrons and a gaseous species that is reactive with the substrate. The substrate can be a Group IV semiconductor . . . or [any] mixture of the foregoing, or an insulating substrate. The reactive species can be any that reacts with the substrate and that volatilizes within the temperature and flow of the device. Typical reactive species to be used are hydrogen, halogens, interhalogen compounds, hydrogen halides, and volatile organic compounds.

(Spec. 7, ¶ 23; '538 Patent 4:13-24, except that the '538 Patent substitutes the italicized phrase, "*on the anode of a direct-current plasma reactor*"; italics and underscoring added.) This passage explains the vital facilitating role of the gaseous species in the Specification's embodiments of the claimed invention.

Thus, the Examiner has not shown that a person having ordinary skill in the art would have had a reasonable expectation of successfully making and using an apparatus as presently claimed for any purpose. While the Examiner seems to presume that Lee's apparatus, which is said to perform **ion etching**, can also perform **electron etching**, the Examiner has not presented a reasonable basis for finding that electron etching does or could occur in Lee's or Hayashi's apparatus. The Examiner has not explained why

one of ordinary skill in the art would have expected, on the basis of Lee (or other prior art of record), that electrons accelerated by the pulse Lee applies to grid **60** would etch a substrate, as required by claim 1. Nor has the Examiner directed our attention to any evidence that indicates that one of ordinary skill in the art would have reasonably expected that argon (Lee 4:22) or CF₄ (Lee 6:22-25) as the plasma source would form a reactive species that reacts with a substrate in the presence of the electron beam. The knowledge that low energy electrons extracted from a plasma might assist or enable a reactive species to etch a substrate, and the suggestion that low energy electrons (e.g., less than 20 eV) might themselves etch a substrate—are, on the present record, based entirely on Appellants' teachings. Thus, the Examiner's position in this case is based on hindsight.

Absent a showing that a person having ordinary skill in the art would have had a reasonable expectation of successfully combining the applied references to make and use an apparatus that performs the function required by the claims, the Examiner has not shown that the invention claimed would have been obvious to a person having ordinary skill in the art in view of prior art teaching available at the time the invention was made.

The Examiner has not satisfied the PTO's initial burden to establish a prima facie case of obviousness of the subject matter defined by any of Appellants' claims based on the combined teachings of Hayashi, Lee, and Kofuji. For that reason, I would REVERSE all the Examiner's rejections.

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Application 10/784,697

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